Research
FOR FARMERS

SPRING—1960

CANADA DEPARTMENT OF AGRICULTURE

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Ottawa, Ontario

HON. DOUGLAS S. HARKNESS, *Minister* — S. C. BARRY, *Deputy Minister*

NOTES AND COMMENTS

Not long ago it appeared that imported insect pests might provide economic control of St. John's wort in the British Columbia interior. This had worked well in California but efforts to repeat the success in Canada have been thwarted by the colder winters in this country. Apparently many of the adult beetles and most of the progeny from fall-laid eggs succumb to the frost and only larvae from eggs laid in the spring survive to attack the weed plants. Undaunted by this disappointment the entomologists are trying again—this time with another species of the same insect imported from a colder country.

* * *

To a man pushing a lawnmower one grass species looks much like another but there are important differences when the grass is eaten by a grazing animal. Chemical analyses of three grass species grown at three different locations in Saskatchewan showed wide differences in protein content both between species and between locations. At Scott, brome grass had 14.5 per cent protein but at Glenbush the percentage was 8.3 and at Glaslyn only 7.2. Comparable figures for slender wheat grass were 11.0, 9.3 and 6.6; for crested wheat grass the percentages were 12.2, 7.3 and 6.8. Percentage protein is not the only factor that determines the value of forage grass but it is an important one. With such wide variations, some thought should be given to choosing the best grass for a given location.

* * *

Every so often an unusually cold winter causes widespread damage to fruit trees in different parts of the country. This is serious enough when a whole season's crop is lost but even more so when the trees themselves are either killed outright or damaged so severely that they take years to recover. The development of hardier trees has been an objective of our horticulturists for many years and worthwhile progress is being made. In two Quebec apple growing districts yields recorded last year showed definite superiority in favor of hardy trees. At Compton the average yield for straight McIntosh trees was 7.5 bushels and for McIntosh grafted on Hibernal trunks 9.9 bushels per tree. At Frelighsburg where winter injury to trees is often more severe, the straight McIntosh yielded 7.7 bushels but McIntosh on Hibernal practically doubled that with an average yield of 15.1 bushels per tree. Should this advantage be maintained in future, it would pay handsomely for the labor involved in topworking on the hardy trunks.

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Cover Photo—V. W. Nuttall, Genetics and Plant Breeding Research Institute, Ottawa, crossing a mosaic and scab-resistant breeding line of cucumber with a bacterial wilt resistant line.

(*See story, page 11.*)

Author examining apples before treatment. Equipment shown was specially designed for research on fumigation under a wide range of environmental conditions.

Low Temperature Fumigation for Insect Control

H. A. U. Monro

FUMIGANTS are useful for insect control under conditions where penetration of the toxicant into the material is necessary to reach the insects. Insecticides in other forms —sprays, dusts, smokes and fogs— are deposited at or near the surface of masses of material so that under many conditions of application they cannot reach the pests inside packages and bulk commodities. However, the fact that fumigants are able to penetrate so deeply and intimately into materials brings about a number of special problems which have to be considered. Much of the work of the Fumigation Section, Pesticides Research Institute, London, Ont., has been devoted to finding out the conditions under which insects may be destroyed by fumigation at low temperatures without injury to the infested material.

The author is a fumigation specialist with the Pesticides Research Institute, London, Ont.

A most important problem is connected with the process of diffusion itself. Not only must the gas penetrate in concentrations adequate to kill the insects during the period of exposure but it must also diffuse away after treatment in sufficient time so that no dangerous or harmful vapors are present when the material is subsequently handled or consumed.

Watch Tolerances

Another problem is that the gases may react chemically with constituents of foodstuffs to produce permanent residues which may sometimes be detected analytically. If these residues are present in amounts in excess of tolerances laid down by Food and Drug authorities, the person responsible for ordering or carrying out the treatment is liable to prosecution. Also, there is the possibility that the fumigant may reduce the nutritive value of the food by reacting with important vitamins.

Temperature has an important modifying effect on the reactions described above. The rate of diffusion of gases varies directly as the temperature. Therefore, it may be expected that gases will diffuse in and out of material progressively more slowly as the temperature is lowered. Against this is the fact that the rate of chemical reaction, of the type concerned in the formation of fixed residues, is reduced as the temperature of fumigation is lowered.

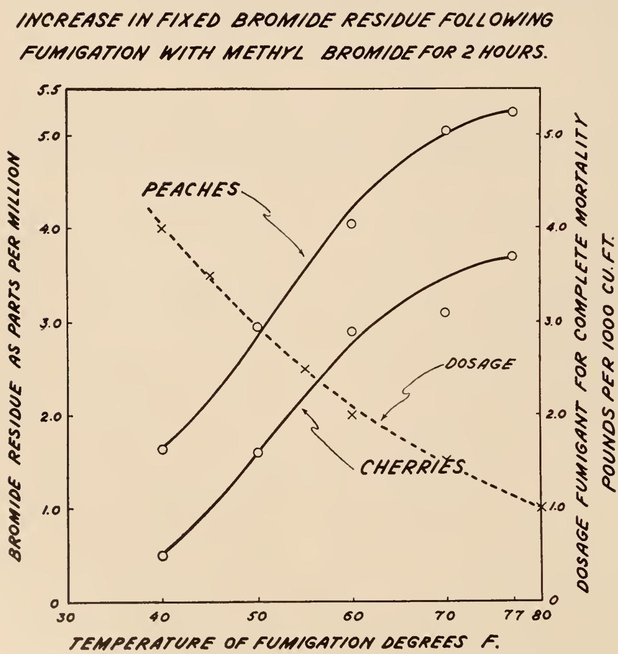
Temperature also modifies the response of the insects to the fumigant. Generally, the insects become less susceptible to most of the common fumigants as the temperature is lowered in the range from 90 deg. F. down to 50 deg. F. Below this, some species or stages

may be weakened by exposure to cold, so that actually less fumigant may be needed to kill them. However, insects that normally live outdoors in Canada, and which are able, in some stages, to survive the Canadian winter, become progressively more resistant to fumigants as the temperature is lowered. Nevertheless, most of the insects experimented with are susceptible to fumigation even at very low temperatures. For instance, a population of the European corn borer, collected in corn stalks north of Montreal, was able to survive winter conditions with temperatures down to minus 30 deg. F. It was found that these insects in bundles of stalks could be controlled by fumigation with methyl bromide at 0 deg. F. The dosage and exposure period required was 12 lb. per 1,000 cu. ft. for 20 hours (a dosage $\times$ time product of 240) as against only 2 lb. for 5 hours needed at 60 deg. F (dosage $\times$ time product of 10). This is an extreme case, but it shows that with certain inert or non-perishable materials such drastic treatments could be carried out if necessary.

So far only a few fumigants have been found which can be used safely on fresh fruits and vegetables and living plant material. There are many compounds with the volatility required for fumigation purposes, which are also toxic to insects. Unfortunately, most of these have unfavorable properties, such as instability and phytotoxicity, which rule out their use in practice. Ethylene dibromide and ethylene chlorobromide are remarkably safe to use on much plant material, especially on fruits. However, as heavy gases they tend to persist as vapors for a long time in material fumigated at low temperatures, a fact which limits their use in this particular field. Hydrocyanic acid gas (HCN) retains a high degree of toxicity to insects at low temperatures, but it is very soluble in water and thus cannot be used widely on fresh material intended for human consumption. HCN has been found to be suitable for fumigation of dormant deciduous nursery stock at temperatures down to 40 deg. F. At present, methyl bromide is the most generally useful fumigant for low temperature work because it is easily volatilized, diffuses rapidly into material, and usually dissipates quickly when a treatment is finished. However, methyl bromide may cause injury, such as spotting and scalding, to certain kinds of fruit. Some varieties of apples, including McIntosh, are susceptible to severe injury under certain conditions. The pertinent properties of these four fumigants are summarized in the accompanying table.

PERTINENT PROPERTIES OF FOUR FUMIGANTS WHICH MAY BE USED ON FRUITS, VEGETABLES AND LIVING PLANTS

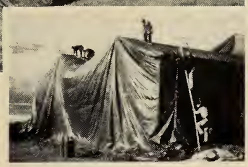
Fumigant	Toxicity and Specificity	Residual Effects
Ethylene dibromide	Highly specific against fruit fly larvae (Diptera; Trypetidae) in fruit. Fruits and vegetables generally very tolerant to insecticidal treatments.	Fixed residues usually very small. Residual vapors may persist for long periods at low temperatures.
Ethylene chlorobromide	Very similar to ethylene dibromide.	Very similar to ethylene dibromide.
Methyl bromide	Moderately toxic to all insects. Fruits, vegetables and growing plants are usually tolerant but there are notable specific or varietal exceptions. Advisable to check literature or conduct experiments before use.	Diffuses readily into and out of most materials, even at low temperatures. Fixed residue may be of importance in some foodstuffs, especially those with high oil content.
HCN (Hydrocyanic acid gas)	Highly toxic to all insects. Not recommended generally for fruit or vegetable fumigation, but has been used successfully on citrus fruits to control scale insects. Also used at low temperatures for fumigation of nursery stock.	Fixed residues usually of no significance, but vapors may persist at low temperatures.



Fixed bromide residues in peaches and cherries following fumigation at dosages of methyl bromide (dotted line) completely effective against oriental fruit moth larvae at different temperatures.

Research Program

Our work has dealt principally with the fumigation of fruit, nursery stock and certain imported commodities such as broom corn. With fruits, the main problems



Fumigation at low temperatures was apparently successful against the oriental fruit moth in B.C.'s Okanagan Valley in 1956. Nylon tarpaulins completely covered the buildings of a cannery while methyl bromide gas fumigant was pumped in at specified concentrations and held 48 hours.

have been control of (*a*) larvae of the apple maggot in export varieties of Canadian apples, and (*b*) larvae of the oriental fruit moth in fruits imported into British Columbia. The actual fumigations against the oriental fruit moth are done at points outside Canada under technical conditions laid down by the Department. We have shown that these insects in the fruits may be killed at the lower temperatures at which the fruits are normally stored or shipped. Apples have been successfully fumigated at 33 and peaches at 40 deg. F. T. Dumas of our Section has made the important finding, already alluded to, that the fixed residues of combined bromide in fruits following exposure to methyl bromide are significantly reduced at lower temperatures even though the dosage required to control the insects has to be increased. (See accompanying graph.) This reduction of fixed bromide residue at lower fumigation temperatures has also been observed in nuts and nutmeats. Methyl bromide is very soluble in oils. Because of their high oil content nuts are likely to acquire high bromide residues from methyl bromide fumigation. By lowering the temperature of treatment these residues may be significantly reduced.

We have investigated the problem of controlling several species of insects in coniferous nursery stock. So far the most important work has been with the European pine shoot moth in certain species of pine. The insects may be controlled in the stock during the normal shipping seasons in both the early spring and fall. If the young trees are fully dormant at the time of treatment, they suffer no injury from the comparatively severe treatments required to kill the larvae of the moth at temperatures down to 40 deg. F.

Orchard near one of the canneries was cut down, crate-supported nylon tarps were spread over the area, fumigant applied (*left background*). Later, stumps were removed, burned.

The fact that fumigation may be done at low temperatures has greatly increased the possibilities of controlling the spread of known or potential pests. When temperatures are low, insects are inactive within the material. Not only will they be unable to escape, but also they are held where the lethal gas can reach them. Knowing that the insects are either dormant, or immobilized by cold, the infested material may safely be transported as far as the border point, or seaport of entry or exit, before treatment is undertaken. Danger of flying or crawling escapees is avoided. A notable example of this is the fumigation of broom corn, which in some years is imported in considerable quantities from Europe and South America. Regulations permit the importation of broom corn only during the eight cooler months of the year when no actively flying or crawling stages of the insects are found in this commodity.

Fumigation at low temperatures enabled an apparently successful defensive campaign to be waged against an introduced pest before it became widespread by adult flight. A population of the oriental fruit moth was accidentally introduced into the Okanagan Valley in the fall of 1956 in imported peaches. The insects were lodged in two canneries and had also been distributed in fruit waste throughout an eight-acre orchard surrounding one of the canneries. During the winter of 1956-57 intensive investigations on the control of overwintering larvae of this insect were undertaken at this Laboratory and also at the Entomology Laboratory, Vineland Station, Ont. It was concluded that fumigation with methyl bromide would be the most suitable method to destroy the insects in the Okanagan in the early spring, before the emergence of the moths. Under the cover of plasticized tarpaulins (see RfF, Summer, 1957), both of the cannery buildings and the eight acres of orchard topsoil were fumigated in late March and early April of 1957, when the air and soil temperatures ranged between 40 and 50 deg. F. The work was completed well before there was any chance of emergence and escape of moths.

These descriptions of some of the practical applications of research on low temperature fumigation show how the apparent disadvantages of our cold climate have in fact been turned to our use in measures designed both to control insect pests and to prevent their spread.

Authar examining Fergusan tomato.

Breeding Tomatoes for Modern Needs

L. H. Lyall

THE tomato is a $14 million crop in Canada; about two-thirds of this return being from the processing industry. The crop requires large expenditures on labor, spray materials and plants, with two-thirds of the labor being required for the harvesting. Labor costs run to $8.00 per ton and represent 46 per cent of total cost of production according to Ontario Department of Agriculture studies made in the four main tomato-producing counties.

In recent years the average tomato yield per acre in Canada was 7 tons, very little more than is required for a grower to break even. In Ontario where approximately 80 per cent of the processing tomatoes are grown the average yield for 1956-57-58 was 7.2 tons per acre. But we know from our variety and cultural trials that with optimum growing conditions and suitable varieties, this yield can be more than doubled.

Since costs of labor and materials are high, anything the plant breeder can do to improve yields and quality will be of great value. To do this the breeder must develop varieties designed for specific purposes and capable of making the most efficient use of their environment. This wide objective is being attacked in its various phases by the Genetics and Plant Breeding Research Institute at Ottawa. In the tomato breeding program at Ottawa and the Smithfield Horticultural Substation objectives include earliness, better flesh color, disease resistance, resistance to fruit defects, and suitability to mechanical harvesting.

The author is a vegetable crops' specialist with the Genetics and Plant Breeding Research Institute, Central Experimental Farm, Ottawa.

Early Maturity

Earlier maturing, high quality varieties are needed by both the processing and fresh market trade. In some areas they are necessary so that the grower can be sure of harvesting the complete crop be-

Above: Paint spray autfit provides an efficient means af applying inaculum of late blight fungus ta tamata seedlings.

Below: Tamata breeding lines susceptible (left) and resistant (right) ta *Phytaphthora infestans* (late blight).

fore fall frosts. Early varieties will lengthen the harvesting and packing season, and so lessen the stress of peak production periods on the processors.

Good early yields of high grade fruit result from a number of factors, including ability to set fruit under the cool night temperatures of early summer, resistance to excessive heat at the time of color formation, and resistance to fruit cracking, sunscald and blossom-end rot.

Fruit Color

Color is especially important with processing tomatoes sold on a grade basis. These grades are based mainly on fruit defects and color—both exterior and interior. With the introduction of instruments for grading color, new varieties must meet the standards set by these objective measurements. The variety Ferguson, introduced from Ottawa in 1955, needs to be left on the vine for a longer period than the John Baer variety in order to develop good flesh color. This may not always be possible and so more rapid flesh coloration is required.

Genes are now available which greatly intensify tomato pigments. Although some of these appear to be associated with undesirable plant and fruit characteristics, they may eventually provide the means for developing more intense color in the tomato.

Resistance to Fruit Defects

Serious losses are suffered in many years from fruit cracking, "yellow-ends", sunscald and blossom-end rot. They bring about a direct loss to the grower in low grade and cull fruits, and the need for more sorting and trimming adds to the processing cost. These defects may result from unfavorable growing temperatures, irregular soil moisture supply, and unbalanced nutrition.

Varieties differ widely in their reactions to these conditions. In the testing of breeding lines at the Smithfield Substation, this has become one of the principal criteria for selection. The Ferguson variety was introduced because of its superior ability to withstand such conditions.

Plant breeder Lyall (left) and food technologist Dr. E. A. Esselbergs, Plant Research Institute, examining a sample of Ferguson tomatoes for peeling characteristics.

Peeling Characteristics Important

Peeling by hand is still common in the preparation of canned whole tomatoes. Immediately after a thorough washing, the tomatoes are dipped in boiling water or treated with live steam. Depending upon the grade of the raw product the length of treatment varies between 30 and 50 seconds. This treatment facilititates peeling but a high degree of skill is required to remove the peel and core quickly. Special coring spoons and trimming knives are used for this purpose. The appearance of canned whole tomatoes is determined mainly by their firmness and it is important not to damage the tomatoes during peeling. The peeling characteristics of a new tomato variety for processing are therefore of importance, especially the thickness and firmness of the outer wall tissue. Generally, small tomatoes are easier to peel without damage than large tomatoes. However, it would take considerably longer to peel 1 ton of tomatoes of 2-2¼ inch diameter than 1 ton of tomatoes of 2½-2¾ inch diameter.

In the first case, there are about 12,300 tomatoes to be peeled, as compared with 7,800 for the larger diameter fruits.

Disease Resistance

Tomato diseases cause heavy annual losses to Canadian growers. It is possible to obtain fairly good control of early blight, late blight, Septoria leaf spot, and anthracnose. However, in commercial practice the difficulties of timing the spray operations and of getting complete coverage of the late part of the crop, often make control measures inadequate. Resistance to these diseases would help greatly to lower costs of spraying as well as preventing much of the direct loss in production caused by disease injury.

Diseases that cannot be controlled by spraying also cause considerable loss to tomato growers. Several viruses are present in addition to the soil-borne verticillium wilt disease. Fusarium wilt is present in many areas of the United States and may eventually be a problem in Ontario. Resistance to these wilts is available and in British Columbia and Ontario resistance to Verticillium wilt is

(Concluded on page 10)

Peach seedling (left) removed from site of old peach orchard and another peach seedling (right) removed from intersite of same orchard.

The Peach Replant Problem in Ontario

L. W. Koch

SERIOUS difficulties are frequently encountered in attempting to replace old peach trees with young ones in established orchards in southwestern Ontario. The situation has created what has become known as the "peach replant problem",- with studies consistently showing that the trouble is more serious in Essex County than in the Niagara Peninsula. Affected trees show stunted growth and yellowing of foliage, and occasionally, replants are so severely affected that they die. Often, in such instances they appear deceptively healthy in the spring but later they collapse and die. Such collapse, however, has been found to be due to the dying-back of most of the newly formed rootlets. Discoloration and death of larger roots are also characteristic of affected peach replants. It has also been observed in Ontario fruit-growing areas where the problem exists that young sour cherry and apricot trees grow satisfactorily in former peach tree sites.

An investigation of the peach replant problem was undertaken at the Harrow Research Station about six years ago. It was begun as a co-ordinated investigation by a team of researchers representing six different branches of science. Such a comprehensive approach was deemed necessary because of the recognized complex nature of the problem. It was obvious from the literature published that previous investigators were divided in their opinions as to the cause and nature of the trouble. Insects, nutritional disturbances, toxic agents, spray residues and nematodes were mentioned as possible causes of the trouble.

Our preliminary examinations of root tissues of affected peach trees soon indicated that special emphasis should be placed on the study of nematodes, soils toxins and fungi as the more likely causal agents of the replant problem in southwestern Ontario. Some of the more important of the findings at Harrow are reported here.

Nematodes and Their Significance

In both Essex County and the Niagara Peninsula, we found that populations of the nematode *Pratylenchus penetrans* were three to four times greater in the soil of orchards with a history of the disorder than in that of other orchards. A direct correlation probably exists between certain physical characteristics of soil and degree of nematode soil infestation. For example, soils of finer texture had lower populations of *P. penetrans* than those of coarser texture. In general, soils of the Niagara Peninsula are finer in texture than those of Essex County. This may explain why successful peach re-

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placement is less of a problem in the Niagara Peninsula than in Essex County.

Intensive field investigations tended to confirm the consistent association of the root lesion nematode, *P. penetrans* with peach replant failure. Severity of the disorder was in inverse ratio to the interval between the removal of old trees and their replacement with new ones. Apparently with the passage of time and in the absence of a susceptible host, populations of this nematode tend to decline. We also observed that the soils of all commercial peach nurseries in Ontario harbored *P. penetrans* and thus nursery stock could readily become the medium for wide-spread dispersal of the parasite.

A critical microscopical study of newly formed roots of peach replants in infested soils showed that *P. penetrans* was the first nematode to attack such roots. Populations of the nematode built up rapidly in the roots and then declined. Concurrently with the decline other types of nematodes were frequently observed in and about the roots but the evidence suggested that their relationship to the disease was much less direct and important than that of *P. pentrans.* When peach replacements were planted in infested soils that had been treated with fumigants, they grew with normal health and vigor.

Toxic Substances and Their Significance

From the start of these investigations soil toxins were given special consideration. Experiments were carried out to evaluate the possible importance of soil toxins and to determine whether the substances produced by the interaction of microorganisms occurring in old peach orchard soils and peach root residues were toxic to living peach roots. Besides the usual chemical constituents found in any woody root, peach roots contain amygdalin, a substance that produces a "bitter almond" flavor, a substance which some microorganisms can utilize as a nutrient. Amygdalin then, suggested possible implications. It was demonstrated that when either peach root residues or chemically pure amygdalin are acted on by certain microorganisms occurring in old peach orchard soils, substances are produced that inhibit the growth of peach root tips. Such substances were not produced when the soils were steamed, thereby killing microorganisms, before amygdalin was added or when other soils were used in which no breakdown of amygdalin had occurred. Again, no such inhibiting substances were produced when other root residues, such as sour cherry, tobacco or pepper roots were added to these soils in place of peach root residues or amygdalin.

The inhibiting substances were readily obtained from peach soil and peach roots by extraction with water and, in addition to inhibiting the respiration of test plant tissues, they also induced darkening and ultimate death of peach root tips exposed to them. Water solutions of amygdalin and its essential splitting enzyme, emulsin, separately and combined, as well as various dilutions of benzaldehyde, an intermediate breakdown product, were also tested. Indications of toxicity were obtained, however,

Retarded growth of peach trees replanted in untreated soil of former peach orchard.

Luxurious growth of peach trees replanted in soil of former peach orchard treated with methyl bromide.

Retarded growth of peach seedlings in old peach tree site as compared with improved growth in intersite. Note stump of old peach tree at entrance right.

only in solutions in which amygdalin was decomposed by the enzyme emulsin and in the various concentrations of benzaldehyde in water. Thus, since such reactions were not obtained in the separate solutions of either the glycoside (amygdalin) or the enzyme, we concluded that microbial action on the amygdalin fraction of peach roots is mainly responsible for the toxic factor encountered in old peach orchard soils.

Besides the toxic substances arising from the microbial degradation of the amygdalin in residual dead peach-root debris, similar toxins may be produced by living roots. This is due to the presence in peach root cells of both amygdalin and its splitting enzyme, emulsin. While the cells are intact, these two components are non-interactive; but as soon as the cells are disorganized as for example by the invasion of parasitic organisms, the two substances interact and produce the toxins and effects described above.

Fungi and Their Significance

The possible significance of fungi in the seeming complex of causes was also investigated. We found that old peach orchard soils harbor representatives of a number of species which, under conditions of low soil moisture and high temperature are capable of parasitizing and destroying peach roots. These results were obtained from greenhouse experiments only, but similar damage to peach roots by fungi would seem possible in the field, given suitable combinations of temperature and moisture.

Generally speaking, however, our investigations did not indicate that fungi could be held primarily responsible for the replant problem.

Control

In view of the findings that certain microorganisms of the soil were so intimately and importantly implicated as causal agents, it seemed logical to assume that if such microorganisms were modified or eliminated, there would no longer be a peach replant problem. Thus considerable emphasis was placed on a soil treatment program that involved the fall application to the soil of various chemicals of known fungicidal or nematocidal capability. Adjudged by the response of peach replants set out in the variously treated soils the following spring, each of the following three soil fumigants proved satisfactory: D-D (Shell) at 32 gal./ac., Telone (Dow) at 24 gal./ac., Vapam at ½ pint in 20 gal./tree. Satisfactory results were also obtained with methyl bromide (Dowfume Mc-2) but its use proved less practical than the materials just mentioned.

Breeding Tomatoes For Modern Needs • • • *(from page 7)*

being incorporated in new varieties for local conditions.

At Ottawa and at Kentville, Nova Scotia, tomatoes are being bred for resistance to the late blight fungus, *Phytophthora infestans*. Two races, O and 1^t have been found attacking tomatoes in Canada. Resistance to race O, the most prevalent, is present in a number of "cherry-fruited" lines, mostly of Mexican origin. This resistance has been transferred to new lines with much larger fruit and these are now being tested for yield and other characteristics. At Ottawa a search is being made for true resistance to race 1^t. Existing breeding lines are being thoroughly examined, and in addition gamma- and X-irradiated lines are being screened in search for resistant mutants.

Mechanical Harvesting

Within the next few years large-scale harvesting for processing may be completely mechanized. This will necessitate maximum yield of good grade fruit at a single harvest. Likely requirements for this will be dwarf or compact plants suitable for close spacing, concentrated ripening period, easy stem removal, high color, and firm fruit able to remain in good condition for an extended period on the vine. The fruits may be smaller than the large-fruited types now widely used for processing. The plants will be set closely in the field and populations may run as high as 10 to 20 thousand to the acre, in comparison with 3 to 4 thousand under the present system. Work at the Smithfield Substation indicates that such plant densities may make irrigation and additional fertilizers essential to good growing practice.

The increasing prevalence of disease, the losses sustained through fruit defects and late maturity, and the possibilities of mechanical harvesting, all point to the need for varieties adapted to new requirements, and constitute a major challenge to the tomato breeder.

Cucumber Breeding

Aim Is To Lower Growers' Costs

V. W. Nuttall

THE successful growing of cucumbers in the field depends to a large extent upon the control of diseases and insect pests common in the major cucumber-growing areas. Spraying and dusting equipment and the frequent application of chemicals substantially raise production costs—but these costs can be considerably reduced by the use of disease-resistant varieties.

Three major diseases, bacterial wilt, scab, and cucumber mosaic cause most of the trouble with field-grown cucumbers. One objective of the cucumber breeding work at Ottawa is the development of both pickling and slicing-type cucumbers, suitable for commercial and home garden production; each type having combined resistance to the three diseases. This program will make available more widely adapted varieties that can be grown successfully in areas where more than one disease is prevalent.

The control of bacterial wilt in cucumber calls for early and frequent application of insecticide to control the cucumber beetles which transmit the disease. Spraying or dusting has to be started as soon as the plants emerge. Insects that spread cucumber mosaic virus must be similarly controlled, but with a different insecticide. These operations are costly, particularly in areas and seasons when climatic conditions favor large and rapid build-ups in insect populations. Foliage fungicides have not proved highly successful in control of cucumber scab or spot rot. As a result, production of cucumbers has been limited to the use of the few available scab-resistant varieties in areas where there is a severe and annual occurrence of cucumber scab.

Also under study at the Genetics and Plant Breeding Research Institute is the possible use of the female-flowering cucumber in the production of F_1 hybrids. First-generation hybrid cucumbers, compared with open-pollinated varieties, have frequently shown superiority in vigor, productivity and uniformity. The high cost of F_1 hybrid seed which ranges in price from 30 to 45 dollars per pound is a deterrent to its wider use. Seed of the commonly grown open-pollinated varieties can be purchased for three to four dollars a pound. In producing hybrid cucumber seed, a common procedure is to grow two varieties side by side in the crossing block, using bees to cross-pollinate. This is similar to production of hybrid corn which is wind-pollinated. Use of the female-flowering cucumber will eliminate the need for defloration (removal by hand of the male flowers from one of the two par-

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Left: Female flowering habit which can be used in the production of F_1 hybrids, eliminating costly defloration. **Right:** Normal flowering cucumber vine with male and female flowers.

ents—comparable with detasselling in corn). The elimination of this hand labor should substantially reduce the cost of F_1 hybrid seed to a price approaching that paid for open-pollinated seed.

In some crops, disease-resistant hybrids have been used as stop-gaps in an urgent breeding program until a true-breeding disease-resistant variety has been developed. We, in this Institute, are working to incorporate disease resistance in the F_1 hybrids, thus speeding up the developing of disease-resistant types.

The mechanical cucumber picker being developed in the United States will likely soon replace the laborious and costly practice of picking cucumbers by hand. The hand labor involved in harvesting cucumbers is estimated to represent more than 70 per cent of harvesting costs. Observations made to date with experimental cucumber pickers in the U.S.A. indicate the possible need in cucumbers for special characters such as long-stemmed fruits that separate readily from the stem, and for long vine sections between the crown of the plant and the first fruiting nodes. Varieties that remain in constant and uniform production will be essential. When these special requirements have been made known to the plant breeder, he will begin "tailoring" the cucumber plant to the desired type that will permit more efficient harvesting by machine. Selection for these special characters will be concurrent with selection for resistance to disease and improved quality.

Above: Inoculating with bacterial wilt to eliminate disease-susceptible cucumber seedlings.

Below: Author inoculating cucumber breeding lines with cucumber mosaic virus to eliminate susceptible seedlings. *Inset:* Close-up view.

Other problems in cucumber breeding require early attention. Resistance to disease such as angular leaf-spot, anthracnose and the mildews is needed in many cucumber-growing areas. There is a need for improved quality in both slicing and pickling types. In slicing types grown for the fresh market, longer shelf-life combined with the high quality of the Marketer variety should be aimed for. In pickling cucumbers, a recent trend indicates a preference for white-spined over black-spined types. Better longstanding quality and better retention of green color in cucumber, which together result in a superior pickled product, are claimed to be associated with white spine. There is a need also in pickling cucumbers for further selection for a high and consistent fruit-setting habit but with relatively slow fruit development. This plant habit would be reflected in an increased production of the smaller size grades which bring top prices.

Left: **The cattle warble or gadfly, *Hypoderma lineatum* (De Vill.) *Center:* Cattle "gadding" to escape the warble or gadfly. *Right:* The cattle warble or gadfly, *Hypoderma bovis* (Linn.)**

CATTLE WARBLES

Can They Be Controlled in British Columbia?

G. B. Rich

SINCE ancient times the elusiveness of the cattle warble or gadfly and the relatively inaccessible habitat of its grubs have retarded the gathering of knowledge of the insect. In 37 to 31 B.C. the Roman writer, Virgil, described both the annoyance of cattle by the flies and the destruction of hides and meat by the grubs. Medieval and Renaissance writers made frequent and pithy references to them. Yet it was in 1776 that De Geer proved that the fly and the grub were different life-history stages of the same insect. It was not until 1914 to 1920 that it was shown that the grub spent the longest portion of its life-history concealed in the flesh of its animal host.

The lack of knowledge and the concealment of the grub has hindered the development of control methods for the cattle warble or gadfly. We now know that the fly lays its eggs on the hair of cattle and after hatching the young larva or grubs bore through the skin into the flesh and migrate slowly toward the back. After 6 or 7 months they arrive under the skin of the back and bore breathing-holes through it. Connective tissue cysts then form around them and they commence growing rapidly; bacteria enter the cysts and produce infections that often cause extensive damage to the surface layers of meat. This is the "warble grub" familiar to most cattlemen. After 2 to 3 months in the encysted stage the grub is mature and pushes its way out through the breathing-hole and forms a pupa on the ground. After 1 to 2 months pupation it emerges from the pupal case as a large, bee-like, non-feeding, short-lived fly. It then mates and lays its eggs on the hair of cattle. Until very recently the grub was inaccessible to control until it had reached the encysted stage when it had already caused extensive damage to the hide and flesh. Thus this type of control was in reality only an attempt to reduce the abundance of flies and so reduce the damage caused by the subsequent reinfestation.

Warble fly emerging from its pupal case.

First successes in warble control involved the use of derris applied to the backs of cattle to kill the grub. Management requirements on B.C. ranches often conflicted with proper timing of applications and reduced the effectiveness of the control program.

In 1956 the chemical industry presented entomologists with organic phosphate materials that showed "systemic" activity against the grubs. These are chemicals that, when applied to cattle either externally as sprays or internally by mouth, are absorbed into the bloodstream and kill the warble grubs during the early part of their development deep in the flesh. This method prevents the extensive

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damage caused by the grubs during the encysted stage and provides a wider latitude during treatment.

The companies producing the systemic materials recommend that treatment be applied as soon as possible after the flies have ceased laying eggs, and their original claims of insecticidal efficiency were based on early treatments. However, under B.C. range conditions the main herds are seldom available for treatment until the snow drives them from the ranges. Thus full herd coverage can rarely be obtained until early winter when weather conditions usually prevent the use of spray. Thus the first problems in the use of systemics in B.C. were the insecticidal efficiency of late treatments and the application of these treatments under existing management requirements.

Our testing at Kamloops was restricted initially to materials that could be administered by mouth in the form of boluses or as additions to supplementary feeds. The most promising of these were Dow ET57, later named Trolene, and Dowco 109. Under normal management practice, when the cattle are removed from the ranges in November or December, a herd is gathered together for calf-weaning, culling of cows, separation into different feeding categories, etc. These gatherings provide the most suitable and economical time for treatment and all treatment programs were co-ordinated with such gatherings.

We found that both materials in bolus form resulted in grub reductions averaging higher than 90 per cent even when treatment was delayed until grubs had commenced appearing under the skin of the back. These treatments could be applied at rates exceeding 120 calves or 80 cows per hour even in freezing weather. Comparable tests showed that even higher grub reductions resulted from the use of the materials as additions to feed supplements. Feeding was at low levels of daily intake of insecticide continued over periods of from 7 to 12 days. This eliminated the need for chute handling. However, under normal B.C. herd management only the younger age groups receive feed supplement and both methods are necessary to provide herd coverage.

In 1959 Dowco 109 was withdrawn from testing and replaced by one of its chemical derivatives named Ruelene. This material is now being tested in feed additive form and in a liquid form injected intramuscularly. The latter is of particular interest in that, although chute handling is necessary, dosage is less subject to error than with spray or feed additive and administration is faster and easier than with boluses.

When it was established that the systemic materials were efficient insecticides and were suitable for use under B.C. ranch conditions the research emphasis was shifted to the longer term effects of their use. In 1957 a five-year program was commenced to study the effect of Trolene bolus treatment of a relatively isolated herd of 1,000 cattle. This herd ranges at distances of not less than 10 miles from areas where neighbouring herds can drop warble pupae. Previous to this program the ranch was notorious for extensive gadding that seriously interferred with summer management of the herd. It also had a long history of heavy louse infestations during later winter and early spring. Since 1957 the herd has been treated with Trolene boluses at the annual mid-December calf-weaning gather except for groups of calves retained for checks on the untreated warble infestation. All grubs have been removed from these check groups by squeezing them out at regular intervals. In 1957 the treated animals produced 77 per cent less grubs than the untreated checks. In 1958 the untreated checks produced approximately 50 per cent less grubs than the 1957 untreated checks. No gadding was observed on the ranges and no louse infestations developed in either 1958 or 1959.

Other Kamloops studies have included the level of reinfestation during the year following Trolene treatment. In one herd animals treated as calves but untreated thereafter had 45 per cent less grubs the following year than animals of the same age group that had never received treatment. It is believed that grubs killed in the tissues cause an immunity type of reaction that makes the tissues antagonistic to grubs subsequently entering them. We are continuing studies of this important aspect.

Of approximately 5,000 cattle treated with these materials three calves have died shortly after treatment. Post-mortem examinations failed to show that these deaths were caused by poisoning but did suggest that they may have resulted from the breaking down of larvae killed in the tissues. This mortality incidence of 0.06 per cent is considerably less than the aver-

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Administering boluses to a cow.

The effect of sorbic acid on surface yeasts and molds. Crock on left is the control untreated stock while one on right was treated with sorbic acid.

Quality Studies on Cucumber Salt Stock for Pickles

A. H. Jones

FIFTY PER CENT or more of the pickles produced in Canada are prepared from salt-stock cucumbers. With immigration boosting the population, particularly by Europeans who are heavy users of pickle products, there is an expanded market for Canadian-made cucumber pickles. Vast areas of land are available in many places across Canada that are well suited to the growing of cucumbers. It remains for enterprising growers and processors to work together and develop the industry. It is important that suitable pickling varieties of cucumbers be developed which can be adapted to conditions in new areas. But it is equally important to produce only high quality finished pickles which will find a ready and stable market. What follows is an account of the Department's quality studies on cucumber salt stock for pickles.

Essentially, the process for curing cucumbers for pickles consists of placing the fresh cucumbers into a salt solution. The concentration of salt used for this purpose is of utmost importance; it must be high enough to prevent the development of undesirable microorganisms and yet low enough to permit the growth of acid-producing types of bacteria.

The salting of cucumbers for preservation is an important commercial process. Because it is usually impossible to process the large volume of cucumbers arriving at plants at the peak of harvest, salting has the advantage that it extends plant operations throughout the winter months. Frequently, salt stock is shipped great distances from an area favorable for growing cucumbers, to processing plants. There is also the opinion held by some processors that salt stock cucumbers make the best pickles since, in the process of curing, the inner tissues of the cucumber become translucent, texture is improved and the skin may become less tough.

A survey made by the Department on the quality of pickles on the Canadian market revealed many defects, a large proportion of which were attributed to faults in the curing process. From studies conducted at Ottawa and at commercial plants in Ontario and Quebec, we found that the critical concentration of salt is between 6 and 7.5 per cent. Generally, the lower concentration is used in areas where the prevailing temperature during the period of fermentation may be lower than normal. At concentrations of salt below 5 per cent, while the fermentation may be more active, naturally occurring antibiotics produced by spore-type bacteria have been encountered. Our studies have shown that these antibiotics may have an inhibitory effect against the acid-producing bacteria so necessary for normal fermentation of the stock.

Cucumbers as received from the field are usually laden with a heterogeneous group of soil-type microorganisms, many of which are capable of initiating fermenta-

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tion and the development of some acid in the stock. However, the growth of a large proportion of these organisms is quickly inhibited by the acid and acid-tolerant types of bacteria, such as lactobacilli, streptococci and leuconostoc. These take over and produce lactic acid in sufficient quantity to prevent the development of undesirable types of microorganisms. At one time it was thought by ourselves and others that these acid-type bacteria appeared in a definite sequence during the fermentation. We now know that fermentation can be started and completed by any one of the three or a combination of the three groups of lactic bacteria. The concentration of acid required to inhibit undesirable types of microorganisms is not nearly so great as was supposed a number of years ago. The critical point appears to be approximately 0.40 per cent. Below this point spoilage of the stock usually occurs. We have found that there is no particular advantage in the production of a higher concentration of acid.

Shortly after fermentation is complete the cucumbers should show almost complete curing. At this stage the salt is built up at a rate of 1 to 2 per cent per week to a final concentration between 15 and 20 per cent. When properly fermented and cured and the final salt concentration maintained, the cucumber salt stock may be stored for years until required for processing. Properly cured stock should show no evidence of softening; the inner tissue of individual cucumbers should appear translucent and the odor should be that of a clean, lactic fermentation.

As long as fermentation proceeds at a normal rate, the quality of the cucumber stock will likely meet the requirements for producing a high quality finished pickle. Unfortunately, many processors, particularly those operating on a small scale and without adequate quality control personnel, eventually will encounter spoilage problems. Improper initial salting or failure to maintain the concentration of salt, and the lack of control of the development of acid are common causes of spoilage. Surface yeasts and molds are serious problems,

Cucumbers damaged by pectolytic enzymes produced by surface yeasts and molds.

particularly where vats of cucumbers are located indoors or under a roof and not exposed to direct sunlight. These yeasts and molds utilize the acids produced by lactic bacteria and in the process of growth elaborate pectolytic enzymes that break down the pectin of the cucumber. The activity of these enzymes starts at the top of a vat and works down through the cucumbers, eventually resulting in complete breakdown of the tissues to a soft, putrid mass. Sorbic acid at a concentration of approximately 0.4 per cent (based on total weight of cucumbers and brine) will prevent this spoilage. The acid must be added at the time of initial salting since it is ineffective against pectolytic enzymes once they have been produced by the organisms.

The characteristics of the finished pickle prepared from cucumber salt stock will vary with the type desired. Actually, the principal function of the cucumber or other products used in pickling is to serve as a carried to convey spice flavors, sugar, vinegar and other condiments to the palate of the consumer. There is no evidence of cucumber flavor in the finished pickle.

Cucumbers in sweet, mixed pickles, a product most frequently desired by the consumer, should be a pleasing green color. When cucumbers are placed in salt solutions for curing the original green color (chlorophyll) changes rapidly to dark olive green, then brown, and towards the end of the curing process, to yellow. The breakdown product of chlorophyll is called pheophytin.

A number of methods have been used to make finished pickles green. Metallic ions such as copper and zinc are commonly introduced into the pickles by passing hot liquor used for covering pickles through pipes or other pieces of equipment containing these metals. This practice is not looked upon favorably by public health authorities. A natural greening of finished pickles will occur with the application of heat and in varying degrees with the addition of sugar, spice oils and other ingredients. By strange coincidence this greening, too, has been associated with the copper ion although in a different way from that outlined above. We found that when copper in the form of sulphate was added directly to the soil or sprayed on plants, there was a definite correlation between the rate of application of the copper and greening of the cucumbers. Although the green color was changed in the curing process to brown or yellow there was also a definite correlation between the intensity of the initial green and subsequent brown or yellow, and the amount of green coloration developed in the finished pickle. Surprisingly, according to chemical analyses, the copper ion added either to the soil or to the plant was not reflected in the mature cucumber. In other words, cucumbers harvested from plots treated with copper showed no significant increase in the concentration of copper when compared with those harvested from the untreated plots.

Cattle Warbles . . . *(from page 14)*

age B.C. rancher is prepared to accept during operations of this type.

Much more extensive studies of the biological and economic aspects of the systemic insecticides are necessary for their proper evaluation. However, it does appear that these materials may become extremely useful tools in the alleviation of this particularly difficult entomological problem.

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